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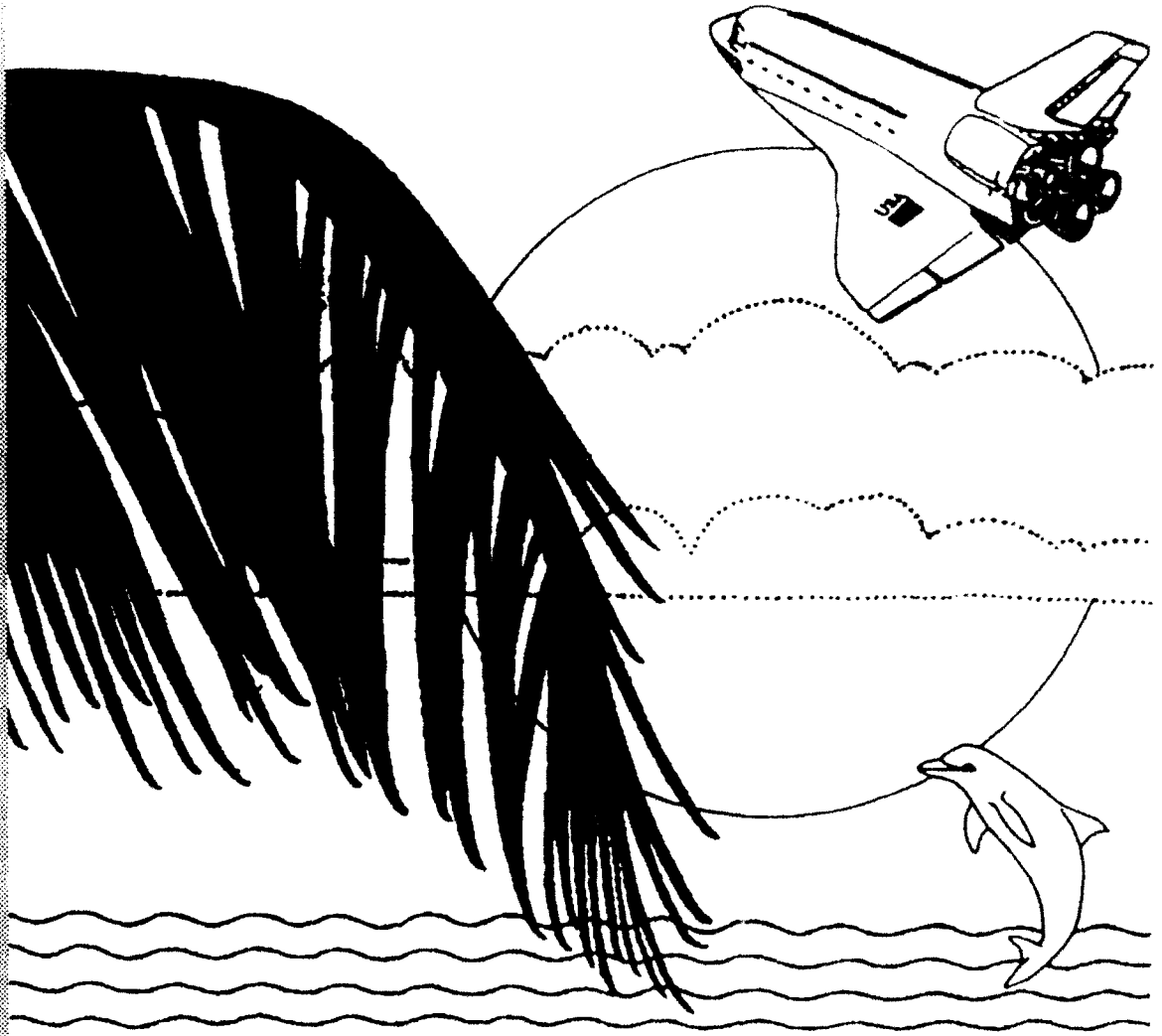

MATH CARNIVAL NIGHTS
(PLANTING THE SEEDS FOR ENGINEERS IN ELEMENTARY SCHOOL)

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ABSTRACT

A good grounding in mathematics is a prerequisite for anyone wanting to become an engineer. However, studies have shown that by high school, most girls avoid math. Many factors, including even toys and books, combine to tell girls they cannot be good at math. One way to dispel this misconception and help increase the pool of young women able to consider engineering is a family-centered mathematics Carnival which can be sponsored by SWE and other professional organizations. Interesting and enjoyable mathematics games help both parents and children see that math is much more than dull school exercises. With each yearly Carnival series, the kids discover that math can be fun, and see that women not only can do well in mathematics, but also use it in real life as engineers. This paper will provide tips for organizing such a Math Carnival.

The Importance of Mathematics

Mathematics is called the language of science. And just as some opt not to learn Spanish or German, many see no need to master the language of mathematics. Unfortunately, there is a major difference between mathematics and other foreign languages. While one can manage to live in California without German, for example, the same cannot be said for mathematics. To keep America competitive in the world market, the emphasis must be on a better math and science education for more students. One study postulated a goal to have 96% of high school students take calculus (as Japan does now).

"When are we ever going to have to use this?" is a common plaint of most math students. In the late 1970's, Hal Sanders, a Santa Barbara Junior High teacher attempted to provide an answer by a survey he documented in an article for *The Mathematics Teacher* in January 1980. He interviewed a representative from each of 100 different occupations to determine what math skills each used on the job. The group covered a wide cross section of occupations not limited to those jobs we normally associate as needing math skills. Those interviewed included an accountant, a graphic artist, an auto mechanic, a carpenter, a police officer, an engineer, a newspaper reporter, a travel agent, a waiter, and a wastewater treatment operator.

All of those surveyed used decimals. The requirements to use a calculator (98%) and the need to calculate percent (97%) were almost as pervasive. Over 80% of those interviewed regularly used math skills in estimation, fractions, and averaging. More than 60% required math skills in ratio and proportion, statistical graphs, formulas, and basic geometric concepts. Mr. Sanders warned that his was a very small cross section, but the need for math skills is clearly demonstrated.

The Mathematical Association of America confirms this in their listing of high school math requirements for various jobs. Students planning to major in business administration, economics, psychology, and architecture need three years of high school math. For a liberal arts major in art, history, law or sociology, the student needs two years of high school math. In order to work effectively as an airline pilot, veterinarian, or astronomer, the requirement is four years of high school math. Even students planning to enter non-math jobs like policeman, fire fighter, carpenter or bank teller, should have two years of high school math to work effectively.

The Problem: Why don't girls like math?

Boys and girls start off equal in math and science performance and interest. Once they enter junior high, however, girls' enrollment, achievement, and interest in science and math begins a continuing downward spiral. Although girls outnumber boys in eighth grade advanced math courses, only half as many girls as boys are enrolled in calculus. Even as recently as 1985, the math scores for women taking the Scholastic Aptitude test (SAT) show girls behind boys at math. Overall, the girls' average in was 45 points lower than that of

the boys. At the high range, five percent of the boys tested scored above 700, compared to only one percent of the girls. After years of study, the Educational Testing Service, which designs the SAT, finally concluded there are no sex-linked differences in math capability. Then why the discrepancy?

The main factors appear to be cultural and social pressures (including toys, books, and games) combined with the effects of teachers and schools. Although it is not as common a belief as previously, some still consider education less important for a woman than for a man. In addition, many children's toys, books, and games continue to foster the old stereotypes. Even at the spring 1992 toy shows in New York, boys' toys emphasized things to do while girls' toys were based on looking pretty or playing mommy. Books often reinforce the old stereotypes. Some are as blatant as omitting women's achievements, or always showing women inept as problem solvers. Others are more subtle: her brother invents things, she just uses them; or the author may use "he/him" as the universal pronouns. Boys' games such as baseball and football involve much use of mathematics. These range from simple arithmetic (how many yards for the next first down) to statistics (batting average, ERA, etc in baseball). And, it's mostly boys who play billiards, computer games and pinball. These not only increase spatial awareness, but provide hands-on experience in geometry and trigonometry. Little girls' games, such as jump rope and "jacks," often require little more math than counting. Thus, girls who play "boys'" games have a definite math advantage over their more sedate sisters.

The lack of math skills in many elementary teachers (predominantly women) can be a double whammy. First, one who is not comfortable with math will have a hard time teaching it, much less making it enjoyable. And secondly, the female teacher as role model causes the girls who do like math to question their enjoyment. And, for many girls, there is no counterbalance for this developing math phobia. In addition, classes are often taught with a "male bias." Boys are called on more often and commended more for their thinking skills; little girls are commended more for being quiet. Math courses are taught the way men and boys think, a subtle factor. The learning modes which are most helpful to girls are seldom noted in teacher education nor included in standard textbooks. Even the fact that girls have problems with math is rarely acknowledged in mathematics methods texts. Thus, the math teacher must first become aware of the problem, then has to search out ways to help girls with math, and finally must work any compensations in to the classroom with little help from curriculum developers or the school administration.

Strategies: Some general ideas

Although the methods texts described above seldom respond to the needs of girls in the areas of mathematics and science, helps are available. The Lawrence Hall of Science at the University of California, Berkeley has developed several programs to focus on the math avoidance of young women, thus increasing their occupational opportunities. EQUALS can be used in the classroom by teachers to increase participation and interest of young women in math. SPACES is another school-based program designed specifically to help girls become more aware of the sciences as career options. Finally, the Family Math program helps families learn about mathematics together. Each program develops awareness and confidence.

Awareness includes understanding the importance of mathematics and the options it opens. This is done not only by relating math skills to various occupations, but also by showing just how much math we take for granted in our daily lives. Estimating, making change, altering the number of servings in a recipe, even modifying the hem in a dress are all mathematical experiences. Even games such as Battleship and tangrams are math-oriented. Sometimes awareness is just showing people how much math they already know. Another aspect is showing that classifying jobs as "men's work" or "women's work" unreasonably limits opportunities and career options. Women engineers and other women in technical fields can provide valuable role models in this respect. By showing that women can succeed in a "man's" career, women engineers free both girls and boys to consider nontraditional options.

Confidence is built on success by starting with manageable problems which gradually become more challenging. Another aspect of confidence building is to emphasize "female" modes of learning. Women tend to emphasize cooperative effort; they are generally not as eager for competition, nor as comfortable with it, as men are. One way to ease young women into competition is by having competition between groups. This can be further enhanced by using both single sex and mixed sex cooperative work groups. Single sex groups provide a chance for girls to solve math problems without the intimidation they may feel in a mixed sex group. This allows a female "math whiz" to become comfortable in expressing herself in the girls group prior to working with the mixed group. Also, there must be balance between the pressure of drilling and reviewing math facts as in a testing situation, and the less structured atmosphere required for understanding. Speed and results are necessary in verifying math facts and in testing situations, but we need to allow time and space for understanding, to let some problems percolate through the mind.

Another confidence builder for girls is the use of manipulatives. Because they tend to be more verbal, girls often don't get the hands on experiences that boys do. Developmental theorists maintain that we cannot grasp the abstract until we can manipulate the concrete. Manipulatives can provide valuable mathematical insights all the way through high school. Nor do they have to be blocks or paper. One exercise is to take a bag of M&Ms(tm) and determine the proportion of each color. Best of all, guess what happens to the candy when you are done?

Family Math Carnival

The Carnival described here is based extensively on the Lawrence Hall of Science Family Math program. Our term "Carnival" suggests fun and excitement with games of chance and skill. Math, *fun math*, is the theme. Parents and children explore problem solving strategies together using hands-on materials in a relaxed atmosphere. The phrase, "parents and children," is very important. We need to get the parents involved so they can continue to reinforce the ideas we will be presenting (and perhaps increase their awareness, too). Thus, the following rule is basic: parents and other interested adults can come with or without a kid, but no child can come without an adult.

This Math Carnival description is aimed towards the intermediate grades through junior high. Girls in this group know most of the math basics, but are at risk of accepting as true the myth of female math inferiority. Our program can make a significant impact at this level. Carnival activities can be slanted toward a younger group also. However, the groups are diverse enough that you will have greater success using separate programs for primary and older groups.

Planning

A school multipurpose room or community center are just two of the possibilities for the location of the Carnival. Another possibility is to coordinate with a local company and use their cafeteria or meeting rooms. Any room can be used as long as it is large enough for several small-group work areas, and can also provide an area for large-group discussions. The furniture must be moveable. If the program is at night, you need to ensure availability of ample parking in a safe area. Since many families have younger children, you will increase attendance if you can provide a separate room and a babysitter for the younger children. The goal is to find a place with either no charge or as small a fee as possible.

Key to success is the Carnival team, which should be as large as you can comfortably use. This is *not* something one person can do alone. The fundamental requirement is that team members enjoy math. Team members should be familiar with the activities being presented, so they can model and explain the activities. Once they've done so, the leaders need to let the participants do everything themselves. Allow participants freedom to do it the "wrong" way. Errors and dead ends can teach a lot. Emphasize that the solution, how you get to the answer, is the important thing. Often, more than one solution exists.

A single session Carnival provides a one-shot improvement in confidence. The optimum is to have four to six weekly sessions, each about 90 minutes long. What you do will depend on how much support you get. For the first time, you may want to have only a mini-Carnival of two or three sessions. By a careful choice of activities, you can create enthusiasm for the next time. Scheduling the Carnival involves selecting both the time of year and the time of day. For some reason, attendance seems to be better in the fall or winter than in the spring. Early evening seems to be optimum, although Saturday mornings are sometimes a good option. You may want to fine tune your schedule by sending out a recruitment notice or flyer to targeted students, including a portion to return indicating their family's preferred day/time.

In some ways, the Carnival is like a nuclear reaction. You need enough participants to provide a critical mass for the exchange of ideas. However, too many participants can cause an explosion, especially if there isn't enough room or materials. Here's where the recruitment flyers can be of real help. You can use the response as an indicator of the possible turn out. An interesting fact is that requesting a series registration fee, even as little as $5 per family, improves attendance. It seems people make a greater commitment to attend if they've paid something. The families usually get back almost the full registration amount in handout and manipulatives to use at home. To ensure that no one who wants to attend is kept away by the cost, keep the fee as small as possible, or offer scholarships.

This brings us to the question of money. Most of the nonrecurring costs will be for your sources of activities (see "Sources" below.) There will be recurring costs for such things as handouts and materials, and possibly for rent, refreshments, and postage for publicity. The cost of the handouts and materials is small; about $5 per family is a reasonable estimate for a six week session. It is often possible to get a place for no rent. Refreshments, such as a pot of coffee, some juice, and maybe cookies, are nice to have. You can either try to get these donated by local businesses, or perhaps team members or parents would be willing

to take turns. Don't be afraid to ask for donations of all kinds. Most businesses, philanthropic organizations, other professional societies, even the local grocery store and gas station find the idea exciting and will do what they can to encourage it. Although school funding has become a chronic problem, but they can still help by lending items such as rulers and scissors.

Putting it all together

Preliminary: So now you have this mass of humanity heading for your meeting room. What now? Plan to be there almost an hour early the first day just to be sure you have everything ready. Hand out name tags as the participants walk in; people who see each other regularly around town often don't know each other's names. Also, you will want to keep a list of those attending. Don't use a boring sheet of standard lined paper; have everyone sign in on a large Venn Diagram. This is a great place to exercise your creativity and at the same time learn about the people who come. Use a differently shaped diagram and different statements for each session.

Openers: People seldom come all at the same time, so you will want to plan a number of simple start-up exercises. One idea is to play a calculator-based version of the strategy game Nim. The object is to be the first (or last) to exactly reach a number by adding (or subtracting) specific digits. If they start at 0 and add 1 or 2 on each turn, the winner is the first to reach 7 without going over. Or start with 11 and subtract 1 or 2, the winner then being the first to reach 0. The game can become more complicated as the participants become familiar with the strategy needed to win.

Tangrams are another good start-up activity. You can duplicate tangram patterns on heavy paper or tag board so each member of the group can make a set to and keep. A simple start is to see how many pieces are needed to make several simple geometric shapes. The next step is to make more complex shapes; check for books of tangram ideas or have the group make their own. Once your Carnival has been in swing for a couple of weeks, you may want to let the participants try to make their own tangram-type puzzles from simple geometric shapes.

Introduction: About 10-15 minutes after your start time, everyone should be well into the spirit of things. Now is a good time to formally introduce the team to the participants and to give them an overview of the evening. If it is the first night, you will introduce the participants to the goals of the Carnival series. Next discuss the opening activity. Let the participants share what they learned. You can add any details or insights they may have missed.

If there were home exercises from the previous week, you may want to discuss the results here. Good candidates for home activities are any which may be too time-intensive to do during the 90 minute session, but which you feel are too good to miss. Some may be outgrowths of previous Carnival experiments. Others may be introductions for future experiments. If a home exercise was planned as a lead-in for a new activity, you may want to hold the discussion in conjunction with that activity.

Activities: As Confucius should have said if he didn't, "It is better to do a few things well than many badly." Limiting activities to no more than three or four per session allows enough time for each group to understand and explore each activity. Plan on 15-20 minutes to do the activity, and allow an additional five or so minutes to summarize and discuss the object or intent of each activity. Note that this summary is held AFTER the participants have completed the activity.

The hard part will be to keep from trying to do too much. One option is have all activities for the session center around a particular area such as spatial visualization. Or, you may want to extend them along time, providing increasingly complex activities for succeeding sessions. Another option to having small groups all do the same thing at once, is to provide a smorgasbord of different work centers scattered about the room. Participants would then spend a set time working at each station with a team leader at each. Provide only as many centers as time slots so everyone gets to each center. For this option, you will need a larger, more open room; with everyone working on something different, it gets really noisy and harder to concentrate.

Many types of activities are available: Word Problems/Logical Reasoning, Strategy Games, Spatial Activities, Patterns, Estimation and Measurement, and Career Explorations. Make sure the series covers some from each. Also, you may want to ask the parents if they have a specific area of uncertainty from their child's curriculum. These can be included in future sessions.

Sponges: For each session, plan a couple of mini-activities for those who finish the regular activities early and want to try something else. Teachers call them "sponges," since they absorb time and energy which might otherwise be lost. These can be different versions of activities you have already explored in the series, or some that just give a quick zing of an idea. Some of the openers work well as sponges also.

An important note: Don't just do something once and then leave it forever. Keep the most popular activities from previous weeks available for revisiting. Repetition of important concepts increases their absorption. Coming back to something you've already mastered can be fun.

Evaluations: Plan to have the participants give you some form of evaluation at the end of each session. This can help you find out about, and change, something that doesn't work. Or, you may want to change the emphasis, such as by responding to the parents' curriculum concerns described above. Another very important use of the evaluations is to tell you if your activities are at the proper level for your group. If they are too hard, you can't meet the goal of making math fun. Do provide some challenging activities, though. It's no fun if the activities are too easy, either. For the first time, plan a mix and go from there.

Sources: Before you buy books, check with the mathematics resource teacher at your local school district; you may be able to borrow some. Or there may be nearby sources, both for these books and others. Also check with your local council of mathematics teachers. In San Diego, the group is the Greater San Diego Mathematics Council. They have a very informative and interesting conference each year, which is where I gathered much of my information.

Once you get started, you will discover more ideas. Magazines such as *Games* and *Provoking Thoughts* (PO Box 1004, Austin, MN 55912, bimonthly, $22/yr) can provide ideas for sponges and sometimes full activities. Museum shops and specialty toy stores often carry math-related games and toys. One of my favorite adult toys is by the David Corporation (P.O. Box 66, Lake Oswego, OR 97034). It's a ceramic egg-shaped oval divided into nine pieces which can be used to make 30 different bird shapes. Magic shops are another great place to look. Many elementary magic tricks just add showmanship to an exploration of topology.

Here are some of my favorites. Many of the books available from the Lawrence Hall of Science (University of California, Berkeley, CA 94720, phone 415-462-1823) give you permission to copy activities from the book for use in your Carnivals. So you don't have to worry about getting permission to make copies or the issue of copyright infringement.

Erickson, Tim, *Get It Together (Math problems for Groups Grades 4-12)*. Berkeley, CA: EQUALS, Lawrence Hall of Science, 1989. (Problem activities for cooperative solving by groups of four.)

Equals, and *More Equals*. Berkeley, CA: Lawrence Hall of Science, 1982 and 1990. (Although designed for the classroom, both of these include activities easily translated for Carnival use.)

Fraser, Sherry, *SPACES (Solving Problems of Access to Careers in Engineering and Science)*. Palo Alto, CA: Dale Seymour Publications, 1982. (A good source of ideas for career explorations)

Perl, Teri Hoch, and Joan M. Manning, *Women, Numbers, and Dreams* Santa Rosa, CA: The National Women's History Project, 1982. (Includes biographies of women in math and science with activities relating to the life's work of each woman.)

Schwartz, David M., *How Much Is a Million?*. New York: Scholastic, Inc., 1985. (A gem of a book with fanciful examples which give a feel for very large numbers. The notes in the back explain how the author developed his comparisons. I've used this one from kindergarten through junior high.)

Stenmark, Jean Kerr, Virginia Thompson, and Ruth Cossey, *Family Math*. Berkeley, CA: Lawrence Hall of Science, 1986. (Includes many activities and additional references. Also lists math topics taught at each grade.)

Good Luck and enjoy yourselves!